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John Wondra
Scott Nunan
Dolores Walters
Michael Bland

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GRAPHICAL INTERFACE FOR THE PHYSICS-BASED GENERATION OF INPUTS TO 3D MEEC SGEMP AND SREMP SIMULATIONS†

John Wondra, Scott Nunan, Dolores Walters, Jaycor
Michael Bland, Lawrence Livermore National Laboratory

ABSTRACT

A graphical user interface (GUI) is under development for the MEEC family of SGEMP and SREMP simulation codes [1,2]. These codes are "workhorse" legacy codes that have been in use for nearly two decades, with modifications and enhanced physics models added throughout the years. The MEEC codes are currently being evaluated for use by the DOE in the Dual Revalidation Program and experiments at NIF. The new GUI makes the codes more accessible and less prone to input errors by automatically generating the parameters and grids that previously had to be designed "by hand". Physics-based algorithms define the simulation volume with expanding meshes. Users are able to specify objects, materials, and emission surfaces through dialogs and input boxes. 3D and orthographic views are available to view objects in the volume. Zone slice views are available for stepping through the overlay of objects on the mesh in planes aligned with the primary axes.

BACKGROUND

The MEEC codes are self-consistent particle-pushing codes that solve the Maxwell electromagnetic equations and Lorentz particle equations using standard finite-difference methods. These codes have been used successfully in the past to model SGEMP and SREMP problems for UGT and AGT experiments. Depending on the environment (vacuum, thin air, dense air) and geometry (2D or 3D), one of nine versions is employed.

The codes had been transitioned from mainframe versions to versions that can run on workstations or high-end PCs. What had been lacking until now was an easy and intuitive way to use the codes and to check the input. Building the MEEC input "by hand" typically involved many hours experienced analysts' time. Verification of an acceptable input file was supported only by a very simple plotted display of zone and object location.

Visualization aids were needed to allow analysts to verify correct object and source locations. Also needed was an automatic mesh generator that could incorporate the physics constraints on meshing the simulation volume well enough to model the SGEMP sources and the coupling to systems.

GRAPHICAL USER INTERFACE

We have used Visual Basic 5 for Windows 32 bit development to create the interface. VB was used because it is the most scalable language to build an application. The support for the language and available tools reduce the development time, and the VB 5 environment allows for developing rich, object-oriented code, as well as on-the-fly debugging. 3D display algorithms were adapted from Stevens [3]. No 3rd party components are used.

The application size is currently 527 kBytes, consisting of 1 main form, 4 modules, 5 dialogs, and 8 classes. Figure 1 illustrates one of the screens, including the main drawing window to the right and a listbar to the left. The user unfolds a topic by clicking on the listbar title, e.g. Sources & Boundaries, Objects & Materials, etc. The pop-up dialog window shown in Figure 1 currently requires users to specify the emission current and average electron energy. These could be automatically computed (in future upgrades) by linking MEEC with radiation transport code such as CEPXS/ONEBFP [4]. The emission levels are input here so that they can be assigned to the surfaces of objects, as indicated in Figure 2.

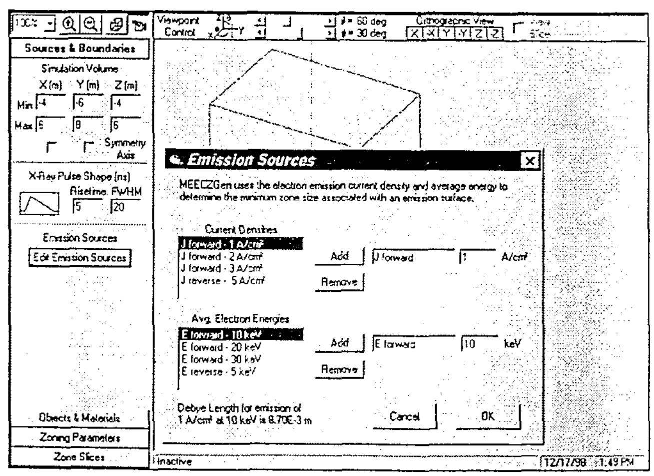

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Figure 1. Example screen for simulation boundaries and dialog for specifying SGEMP emission currents.

Figure 2 has a wire frame of an example satellite in the main drawing window and the dialog shows the emission surfaces that the user has assigned to the center body object. Note that the two surfaces that have been selected as emission surfaces are marked as such by the program, which applies has marks to the surfaces. Simple shapes such as boxes, planes, rods and wires can be selected and sized for dielectric, metal and lossy (finite conductivity) objects. [Other simple object shapes, such as cones and frustums, might be added in future upgrades. Other materials, such as inductors, could be included as well].

Users may specify several types of materials by setting different property values for each one, including name and display color.

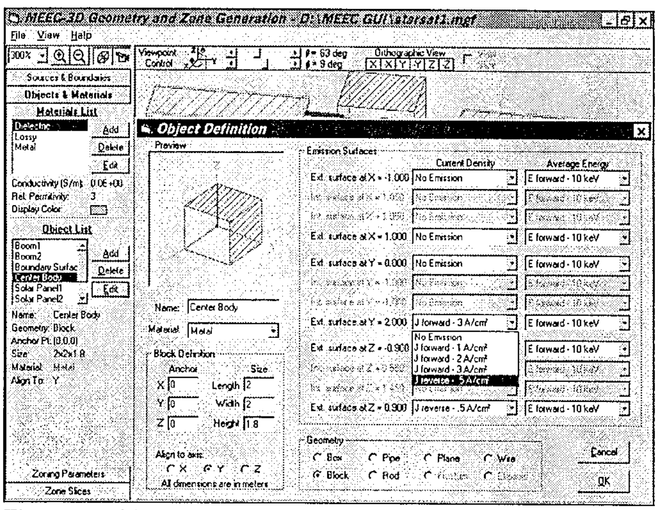

Figure 2. Object wire frame display and assignment of emission surfaces.

Figure 3 shows the 3D display of the simulation satellite with surface color turn on. Controls at the top of the window allow the view to be rotated to an arbitrary viewing angle and zoomed in or out.

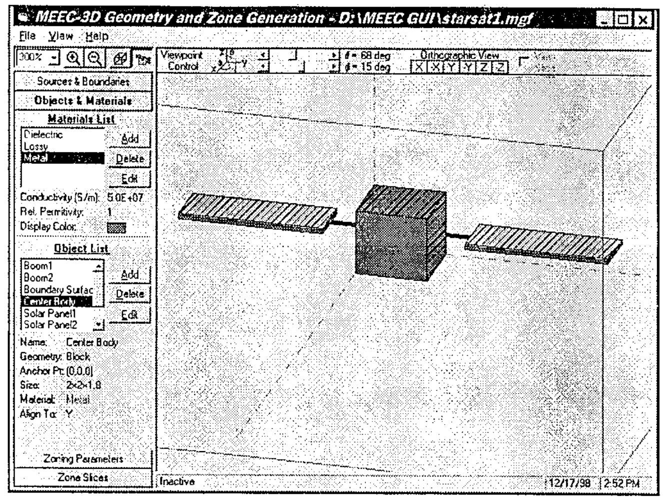

Figure 3. 3D rotatable display of user-defined objects and simulation volume.

MESH GENERATOR

We have developed algorithms for generating the Cartesian grid. The mesher takes each axis and defines zones from one object surface to another, taking care to make zones sufficiently small near emission surfaces. For example, vacuum SGEMP simulation requires resolving the space-charge that builds up in a layer $\lambda = \varepsilon_0 \sqrt{\frac{e}{8 m_e \pi}} \left(\frac{E_e^{3/2}}{J_e} \right)^{1/2}$ next to an emission surface. The mesher will use fine zones ($<\lambda$) near the emission surface. Grid expansion rates will be set at reasonably adequate sizes (< 1.4 growth rate is, for example) to minimize numerical dispersion in the region of interest.

Figure 4 shows example mesh generator results in the GUI. Users may override the code choice for minimum and maximum zone size as well as growth rate. The code will issue warnings when such choices may lead to poor simulation results. One can quickly use the dialog options to trade off mesh size with total number of zones. Depending on the constraints of the computer running the MEEC simulation and the desired turn-around time, one may want to keep the total zone number below a certain level.

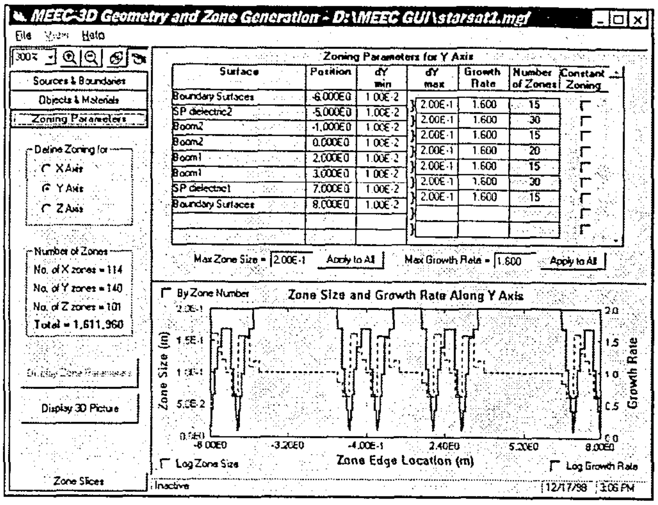

Figure 4. Mesh generation results for a sample problem.

Figure 5 illustrates an example of the zone slice view that will allow users to step through each layer of the simulation mesh, examining the placement of object boundaries and output requests (i.e. fields or currents developed at that zone).

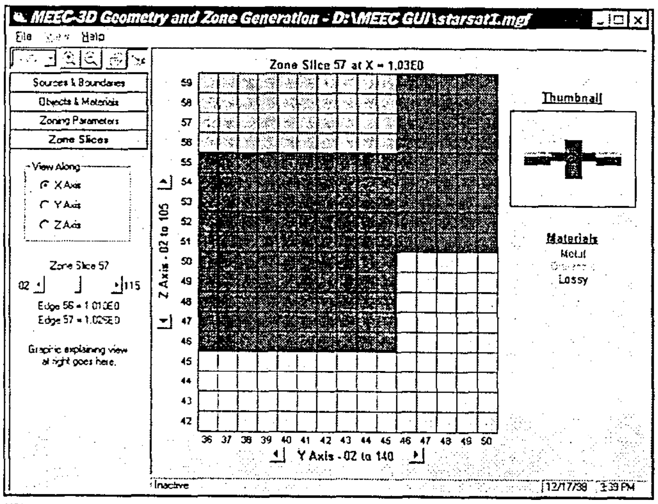

Figure 5. Zone slice view (example)

The screen examples of the mesher results are currently stand-alone prototypes – linking the mesher with the user-defined VB objects is in progress. The paper (and code demonstration) will show the use of the new GUI and mesher to develop the input for a reasonably large SGEMP problem, the STARSAT West Bay, which required several days to craft by hand in years past. The GUI-generated input file will be used to run the MEEC simulation in order to get sample results that can be compared with prior results.

MEEC INPUT FILE

Figure 6. MEEC input file written by GUI

SUMMARY

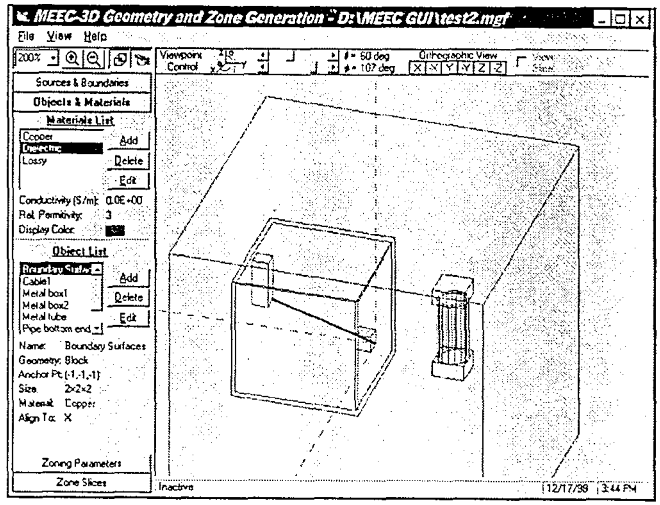

Figure 7.

Figure 5. Zone slice view (example)

MEEC INPUT FILE

The new MEEC GUI writes a MEEC input file when the problem objects and zoning have been defined to the user's satisfaction. The output file is an ASCII text file with standard key words used by MEEC. Figure 6 indicates a portion of the file generated by the GUI for the simple satellite example. The GUI prompts the user for header information to identify the file and then writes out the zoning and material definitions.

At present, the emission surfaces and output requests are not generated by the GUI but must be added by hand to the file, following the MEEC format. Future development of the GUI could generate these missing pieces to fully automate the MEEC file generation, and then run MEEC to perform the simulation.

Future efforts may include extending the MEEC GUI beyond the vacuum SGEMP 3D version to the versions employing other geometries and plasma effects (thin-air SGEMP and SREMP models).

```
MEEC-3D INPUT FILE
SGEMP ON SATELLITE ILLUMINATED AT LOW FLUENCE, EMISSION
FROM SOLAR PANELS AND TWO SIDES OF CENTER BODY
*
MAXWELL CIRCUIT                                              zone edges
GEOMETRY = CARTESIAN
X ZONING =        -4.0000E+00, -3.9900E+00, -3.9742E+00, /
     -3.9494E+00, -3.9102E+00, -3.8485E+00, -3.7513E+00, -3.5980E+00, /
     -3.4307E+00, -3.2307E+00, -3.0307E+00, -2.8307E+00, -2.6307E+00, /
     -2.4307E+00, -2.2307E+00, -2.0307E+00, -1.8307E+00, -1.6307E+00, /
     -1.4307E+00, -1.2307E+00, -1.0307E+00, -8.3073E-01, -6.3073E-01, /
     -4.3073E-01, -2.6295E-01, -1.5810E-01, -9.2560E-02, -5.1600E-02, /
     -2.6000E-02, -9.9997E-03,  0.0000E+00,  1.0000E-02,  2.5066E-02, /
      4.7764E-02,  8.1962E-02,  1.1648E-01,  1.5744E-01,  1.9840E-01, /
```

...(more zones for x, y, z axes)...

```
*
* Center Body                                 conducting volume
*
CV ( 0.00, 0.00, 0.00) TO ( 2.00, 2.00, 1.80)
*
* Solar Panel1
*
CV ( 0.25, 3.00, 0.95) TO ( 1.75, 7.00, 1.05)
*
* Solar Panel2
*
CV ( 0.25, -5.00, 0.95) TO ( 1.75, -1.00, 1.05)     dielectric volume
*
* SP dielectric1
*
DV ( 0.25, 3.00, 1.05) TO ( 1.75, 7.00, 1.10) EPS = 2.6562E-11
```

...(more object definitions, followed by run parameters such as time step)...

Figure 6. MEEC input file written by GUI (currently, user adds emission surfaces and output requests "by hand"

SUMMARY AND CONCLUSIONS

This paper has described the development of a preliminary GUI and grid generator to produce the critical input for the MEEC SGEMP and SREMP codes. The intent has been to speed the modeling process by providing basic visualization tools and to prevent errors by automating what had been a tedious manual generation of objects and mesh. Also, some SGEMP analyst experience has been included in the choices and criteria used to cast objects onto a mesh and to choose the mesh size based on the SGEMP physics that needs to be accurately resolved. This "automation" of SGEMP simulation does not take the place of analyst insight into model inputs and interpretation of the results. It should, however, increase the reliability of basic input construction and provide simple error checks for complex simulation geometries.

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